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Working Notes

To John C.

STAT From [redacted]

Subj. Program description and plan for the holographic interferometer and coherent processor.

Date 8 July 1970

Declassification Review by NGA/DoD

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Working Notes

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Summer Program
Working Notes
Holographic Interferometer and Coherent Processor

The status of this program is such that longer term definition of program direction can be made. This is beneficial especially within the context of the summer months when STAT [redacted] and STAT [redacted] will be able to continue this work.

Present Status

The holographic interferometer has been set-up and operated for purposes of generating filters for target recognition and image manipulation. The coherent optical processor was set-up and operated for applications in the manipulation of imagery, including the use of the holographic filters for target recognition and blur removal.

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The initial filters generated for these purposes are matched filters, being directly related to the complex conjugate of the image function under process. At present other forms of filters are being generated. This direction is taken to analyze the response obtained from different forms of filter functions. The two new forms are another method for generating a matched filter and an inverse filter. The inverse filter is the inverse of the function to be filtered. The past performance and present status is outlined in table 1.

Based upon the present status of this program we have initiated a preliminary evaluation of the results to date and the direction that can be taken during the summer months [illegible] the holographic

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system can be operated by the co-op students, under direction. The results of this evaluation place the past and present effort into proper context with coherent optical image manipulation techniques, and specify a series of analytical and experimental investigations to ensure thorough evaluation of these techniques.

Outline of Preliminary Evaluation

The holographic filter is recorded on film and depends on the response curves of film for an accurate recording. When film is processed to a specific gamma, the assumption that linearity is obtained is bounded by linear limits of the sensitometric response. The hologram consists of an interference fringe pattern superimposed on a certain

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filter function, but the modulation response of film varies as a function of exposure; thus the fringe pattern is modulated other than the linearity often assumed in an analytical description. Finally, film resolution threshold varies as the input signal modulation and the interference fringe pattern can be lost at certain regions of exposure. Since the optical diffraction is a function of the modulation recorded on film, the effective filter function is thereby affected by the fringe modulation variations of film response.

The significant curves are illustrated in Fig 1. Note that the film response to an input modulation is a function of log exposure as well as the frequency of the input modulation,

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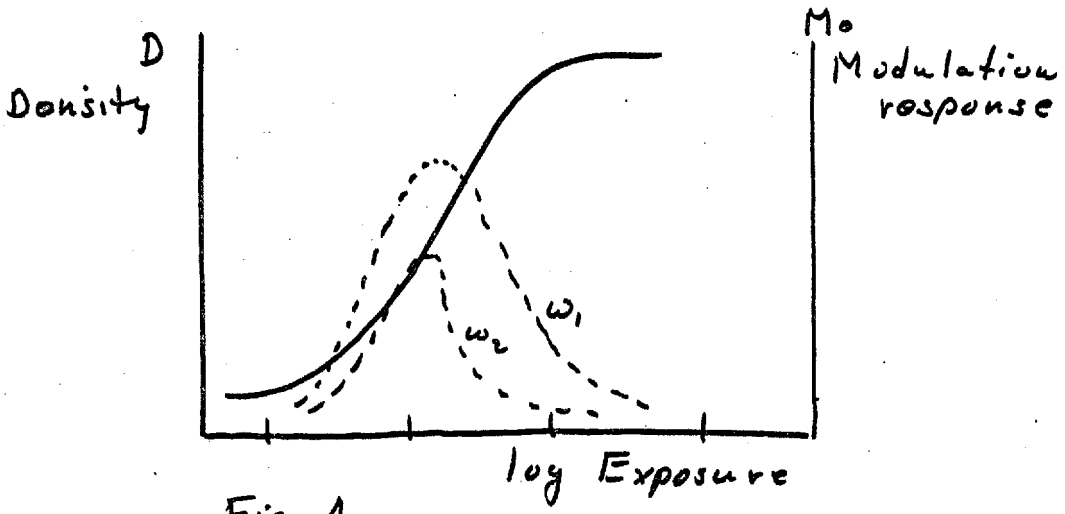

Fig 1

Film density response vs. log exposure (solid line) and modulation response vs. log exposure (dashed line).

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noted by ω. The higher the frequency, the lower the film modulation response and the narrower the range of response.. As illustrated, $\omega_1 > \omega_2$. These modulation response curves are directly related to the MTF curves of films, specifying the cut-off and modulation with exposure. The film MTF is illustrated in Fig 2, for a particular exposure of the input modulation and

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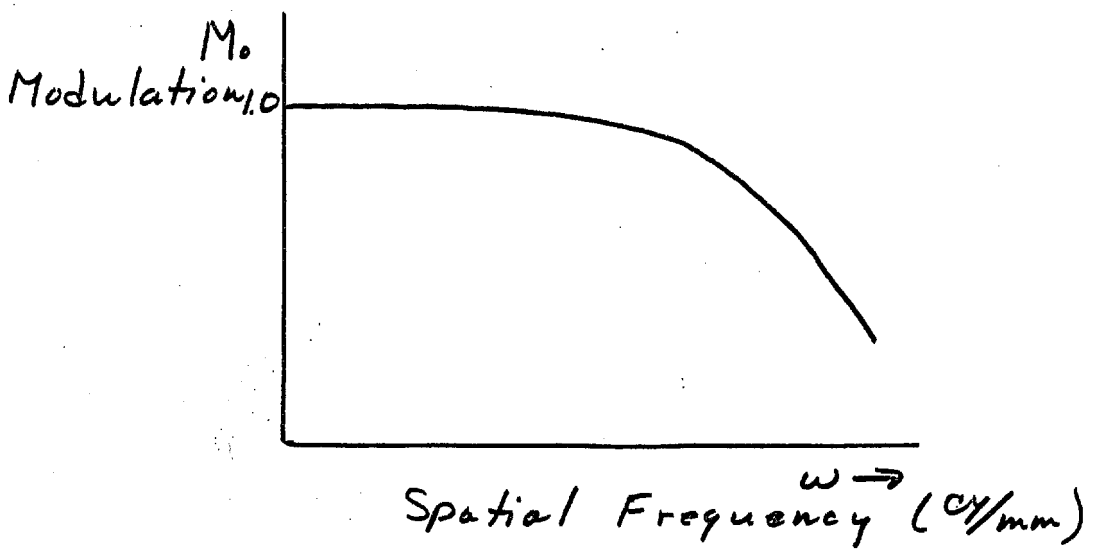

Fig 2. Film MTF for a given exposure and process.

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a particular film process. Given these facts, we should now be able to determine the expected response for a given exposing function and holographic interference frequency.

Fig 3 illustrates the method by which the transmittance of a filter can be determined. Fig 3(a) is the output transmittance resulting from the film transmittance vs exposure

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curve (Fig 3(b)) and the input exposure function (Fig 3(c)). An even more significant

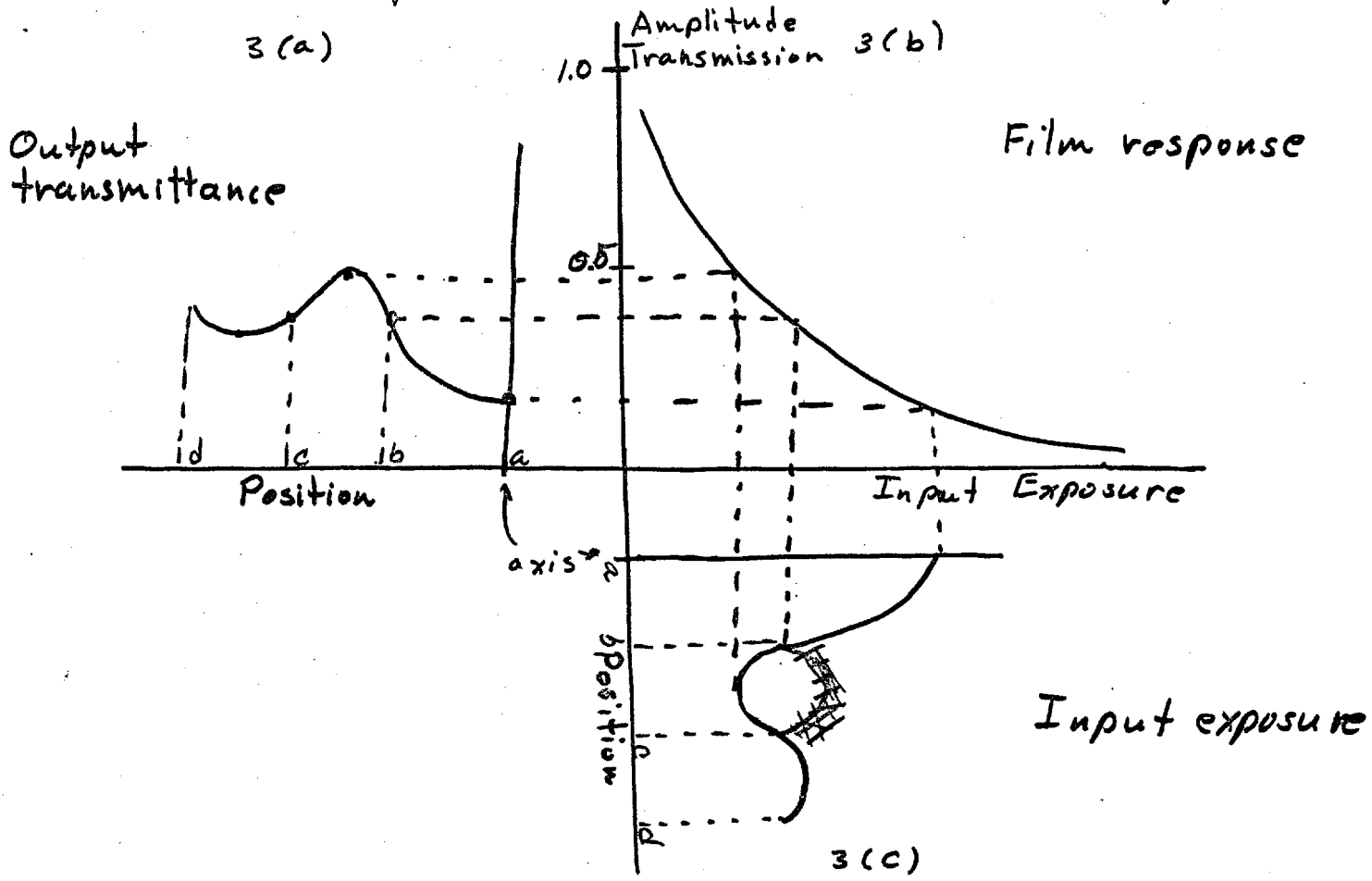

Fig 3 Determining film transmittance response to an input exposure.

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response is the modulation that will be superimposed on the output transmittance function. This can be determined by combining Fig 3(c) with the

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dashed line response curve in Fig 1 for the fringe frequency of interest. This is illustrated in Fig. 4 where (a) is

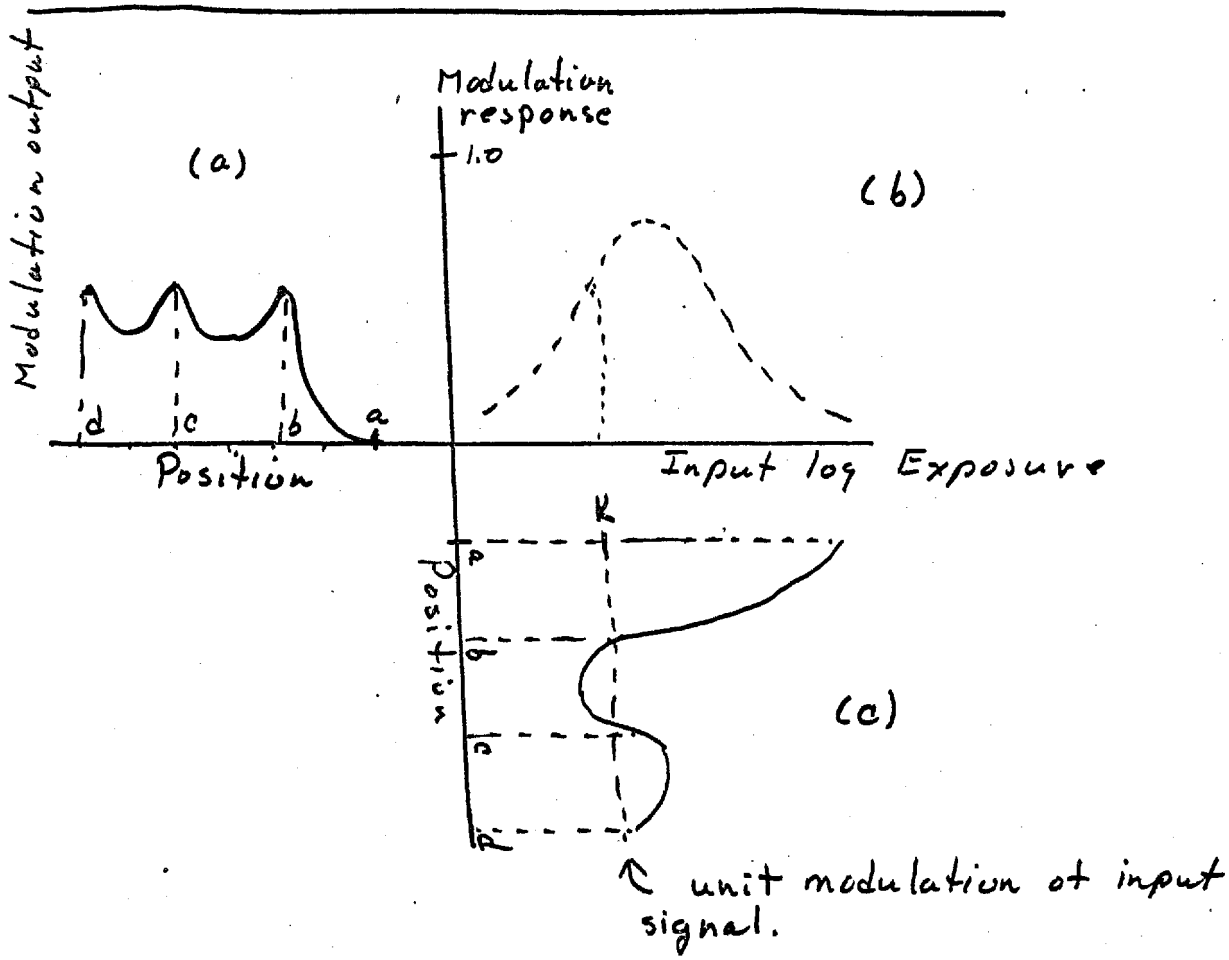

Fig 4 Determining modulation on film containing holdyram of function.

the modulation on film, (b) is the modulation response of the film at frequency ω, and (c) is the logarithm of the exposure.

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The effective filter is then the result from Fig 4(a) and Fig 3(a). The diffraction of light is dependent on the energy passed by the film (amplitude transmittance) at a particular area, and the modulation of the recorded pattern. This is expressed by

$$F(\omega,\nu) = \tilde{T}_A(\omega,\nu)\cdot M_A(\omega,\nu)\cdot K$$

where $\tilde{T}_A(\omega,\nu)$ is the amplitude transmittan of the film described in Fig 3(a), and $M_A(\omega,\nu)$ is the modulation (in amplitude) described in Fig 4(a). Taking these curves we see the result of a simulated effective filter $\hat{\mathcal{E}}(\omega,\nu)$ response in Fig 5. This describes the

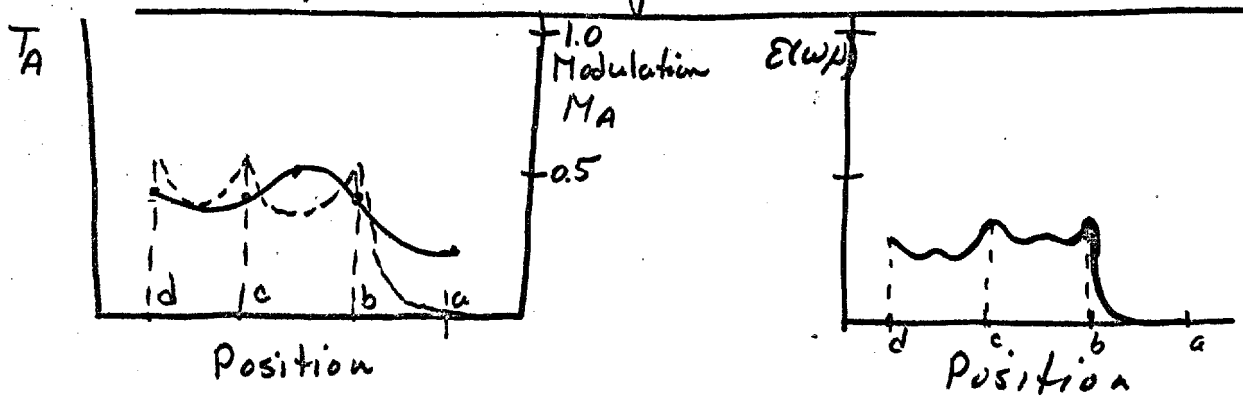

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Fig 5 Method to determine effective filter.

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diffracted energy of the holographic filter.

By the technique outlined here we can evaluate the accuracy to which a function can be holographically recorded. We should use parameters of present films, compare them with expected responses from extended dynamic range processed film, and determine optimum ways for holographic recording.

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Table 1

Program Status

	April 24	1	8	May 15	22	29	June 5	12	19	26	July 3
Interferometer set-up	////	////	////								
Fabrication of Fresnel holograms			////								
Coherent Processor set-up				////	////						
Generation of test imagery					////						
Generation of quasi-matched filters by Fourier Transform holographic technique						////	////				
Application of technology to target recognition for system tests and demonstration							////	////	////	////	
Generation of blurred imagery for tests.								////	////		
Generation of blur compensating quasi-matched hologram filters								////	////	////	
Preliminary evaluation									////	////	////
Generation of holograms for matched and inverse filters											////

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Working Notes

Program Plan

Time Period:- July - Sept. 1970

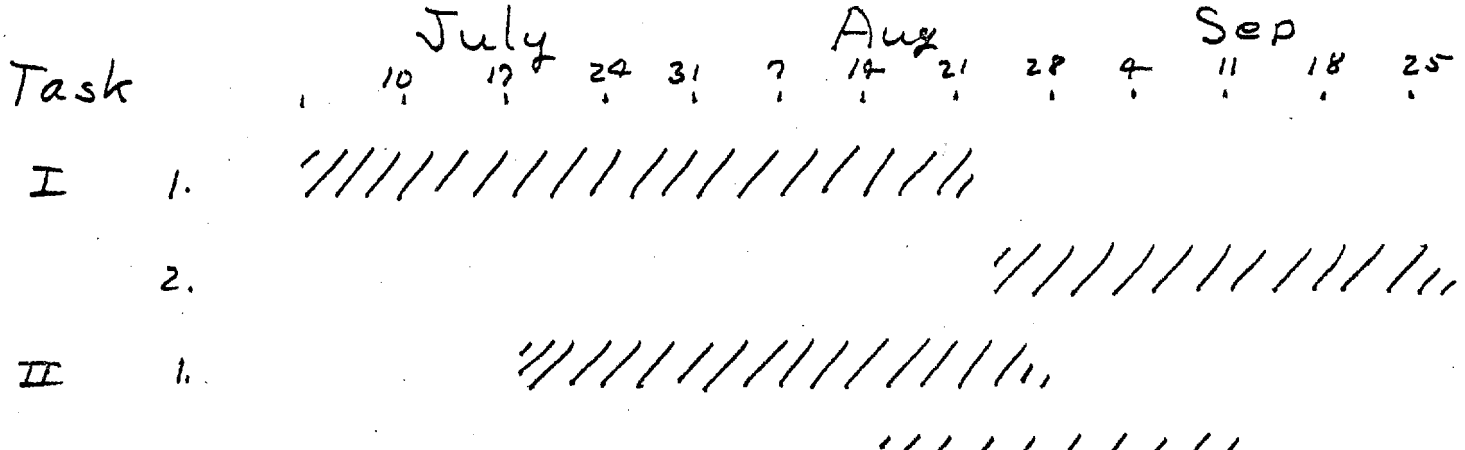
Tasks:- I) Experimental

1. Fabricate & evaluate matched and inverse holographic filters.
2. Determine best results for application to image manipulation, including quasi-matched, matched and inverse holographic filters.

II) Analytical

1. Obtain required film data, or best estimates, for evaluating film capability for holographic recording.
2. Perform evaluation for correct γ processing of film and for extended dynamic range processing and determine which method can most accurately record holographic filters.

Schedule



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I/T

Memorandum

To: John C.

STAT From: [redacted]

Subject: Laboratory Program Plan for the two week period, 15-26 June.

Date: 12 June, 1970

STAT Ref. no. [redacted] 2201201-A5-8

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Laboratory Program Plan
June 15 & 26, 1970

The following program outline and schedule is provided as a basis for continuing STAT development activity in the STAT [redacted]. The effort will include, in general, four primary objectives:-

1. Processing and sensitometry of film.
2. Fabrication of inverse hologram filters.
3. Maintenance of optical benches & facility
4. Alignment and test of coherent bench.

This document covers objectives 1, 2 & 4. The third will be handled by STAT [redacted]

1. Repeatable processing of Micro-file film to $\gamma = -2 \pm 0.2$ is required for fabricating inverse hologram filters on the interferometer. The process to $\gamma = +2 \pm 0.2$ has been accomplished during the past several weeks. Use the

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same methods of measurement (sensitometer step wedge exposures measured with MacBeth Quantalog densitometer) for setting-up this process. The process is :-

Reversal Processing of Microfile to $\gamma = 2$

1) Develop DK-50, 1 part to 2 H_2O, 5 min, 68°F, normal agitation (Normal agitation is continuous first 30 seconds, 5 sec. each 30 seconds thereafter.)
2) Rinse in water, 30 seconds.
3) Kodak Direct Positive Bleach, 3 min, normal agitation
4) Water rinse, 1 min.
5) Kodak Direct Positive Clear Bath, 30 sec. constant agitation
6) Water rinse, 30 sec.

Open can — expose all film to a high intensity lamp uniformly and thoroughly. Replace on reel and into can

7) Repeat no. 1
8) Repeat no. 2
9) Rapid fix, 2 min, constant agitation or normal fix for 5 min.
10) Rinse in water, 1 min.
11) Hypo neutralizer, 1 min.
12) Water rinse, 1 min.
13) Photo-flo & dry.

Record data in notebook. If γ is too high, decrease time of development & if too low increase time of development.

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2. Fabrication of inverse hologram filters.
Record two outputs on the interferometer.

a) Block out the reference wave and record the spectrum at the slit on micro-file film. Record a full range of exposures so that the spectrum is recorded from low to high exposure, in about 5 steps. Low exposure is that when the first side lobe becomes evident. Use exposure steps that increase by a factor of 3 in exposure. Process the film to $\gamma = +2$ (direct processing) Try a test run at first to determine expected exposure times.

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b) Record the spectrum with the reference wave, using Recordak Micro-file film. Process this by reversal processing to $\gamma = -2$. Several samples of the balance of the signal beam and reference beam can de obtained by using N.D. filters 1, 1.3, 1.6 in the reference beam. Best exposure is known when the recorded holographic spectrum has interference fringes (straight lines visible when the reference beam is illuminating the spectrum) starting at the first order side lobes and continuing out several lobes. Use the N.D. filters as

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performed in recording the filters on 6/10/70. This changes the amount of light from the reference beam. An exposure series for each N.D. filter is required, with about 5 exposure samples above minimum, a factor of three in exposure between samples.

4. Alignment and test of optical bench. The optical bench will be cleaned, based upon the maintenance procedure taken. The components must be set-u and aligned. We will support you in this activity by demonstrating the technique (note schedule). Alignment is essential to the optical system operation. The technique

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we use is Boy's point alignment, the method required for alignment of components of a complex lens. The test for this alignment is to note presence of Boy's points in front of, and behind each lens, centered on the shadow of the cross-hair shadow defining the optical axis. This set-up and alignment will also require critical focusing techniques, based upon auto-collimation and normal focusing. These will be demonstrated. The techniques can then be repeated and tested.

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Schedule

Item no.	Date 15	16	17	18	19	22	23	24	25	26
1. Sensitometry	x	x	x	x	x	x	x	x	x	x
2. Fabricating filters	x	x	x	x	x	x	x	x	x	x
3. ———										
4. Alignment + test†							x	x	x	x

† The alignment and testing of alignment demonstration is scheduled for 23, 24 June The technique can be repeated on 25, 26 June. Questions concerning items #1 + #2 can be brought up on 23, 24 of June, or earlier, if necessary, by phone.

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